

## FUEL SEALING STRUCTURE

### TECHNICAL FIELD

[0001] This invention relates to a fuel sealing structure.

### BACKGROUND ART

[0002] It is known to interpose an annular packing between an opening part of a container such as a fuel tank and a closure in order to prevent the leakage. FIG. 10 of Japanese Patent Application Laid-Open No. 2002-337916 discloses a packing having a uniform thickness. This packing is interposed between an annular sealing surface on an opening part of a container and an annular sealing surface of a closure. The two sealing surfaces are planar surfaces (planes) which are parallel to each other. At the time of attaching the closure, the packing is uniformly compressed by the two sealing surfaces. The two surfaces of the compressed packing are adhered to the seating surface on the container and the sealing surface on the closure with a predetermined pressure, respectively, thereby preventing the leakage of fuel.

### DISCLOSURE OF THE INVENTION

#### PROBLEM TO BE SOLVED BY THE INVENTION

[0003] In the fuel sealing structure of the Japanese Patent Application Laid-Open No. 2002-337916, in case the packing is thick, the amount of the gasified fuel permeated through the rubber material of the packing is

increased. In order to restrain the amount of permeating fuel, it is necessary to reduce the permeating sectional area by making the packing thinner. In case the packing is made thinner, however, there arises another inconvenience. This inconvenience will be described with reference to FIG. 7.

[0004] FIG. 7 shows the changes of compression ratio of the packing in accordance with movement of the closure in the axial direction. In FIG. 7, the axial movement of the closure from the time the attachment of the closure is started until the time the compression of the packing is started is omitted. In other words, the amount of movement of the closure is set to zero at the time of starting of the compression. As the closure is moved in the axial direction, the compression ratio of the packing is increased. This change, in case the packing is thin, is great compared with the packing that is thick.

[0005] At the time the closure is pushed in for a predetermined amount, the attachment of the closure is completed. There can be found some error in amount of axial movement of the closure until the closure reaches the attachment completing position. As mentioned above, in case the packing is thin, the change of compression ratio of the packing is large per unit of movement of the closure. Accordingly, the error of compression ratio becomes large corresponding to the error of the amount of axial movement of the closure, and there is a possibility that the error of

compression ratio is out of the allowable range of error. When the actual compression ratio of the packing exceeds the upper limit of the allowable range of error, breakage of the packing occurs, and when the ratio becomes lower than the lower limit of the allowable range of error, the adhering force between the packing and sealing surfaces of the container and closure is lowered and thus, the sealability of the liquid fuel is lowered.

#### MEANS FOR SOLVING THE PROBLEM

[0006] To solve the above problem, the present invention provides a fuel sealing structure comprising a container for storing fuel and having an opening part, a closure attached to the opening part of the container, and an annular packing interposed in a compressed condition between an annular sealing surface of the container and an annular sealing surface of the closure, wherein the sealing surfaces of the container and closure each include an annular first region and an annular second region disposed radially inside or outside of the first region, and a distance between the second regions of the two sealing surfaces is shorter than that between the first regions, the packing includes a first sealing part sandwiched between the first regions of the two sealing surfaces and a second sealing part sandwiched between the second regions of the two sealing surfaces, the first and second sealing parts are, in their compressed condition, interposed between the sealing surfaces, the second sealing part is smaller in thickness than the first sealing part in a natural condition, and this difference in

thickness is larger than the difference between the distance between the first regions and the distance between the second regions.

[0007] Owing to the above construction, in the first sealing part, the change of compression ratio with respect to the amount of axial movement of the closure is gentle, the compression ratio can be managed with a comparatively high precision, and the change of compression ratio can be set within an allowable range. As a result, the packing can be adhered to the sealing surface of the container and the sealing surface of the closure with a sufficient pressure without the occurrence of breakage of the packing, and the leakage of liquid fuel can reliably be prevented. In the second sealing part, since the packing is smaller in thickness than in the first sealing part and the permeating sectional area is small, the permeation of the gasified fuel can be restrained. Moreover, since the difference of thickness between the first and second sealing parts is larger than the difference between the distance between the first regions and the distance between the second regions, the amount of compression of the second sealing part is smaller than that of the first sealing part, the overly compression of the second sealing part can be avoided, and the breakage of the packing at its second sealing part can be prevented.

[0008] Preferably, a compression ratio of the second sealing part is smaller than that of the first sealing part when the closure is in an attached condition. Owing to this arrangement, even if some error occurs at the

attaching position of the closure, the overly compression of the second sealing part can reliably be prevented.

[0009] Preferably, the first sealing part is located radially inside of the second sealing part. Owing to this arrangement, the liquid fuel is prohibited in the first sealing part and does not reach the second sealing part. Thus, the second sealing part can limit its task only to prevention of permeation of a small amount of gasified fuel, the amount of compression can be reduced extensively, and breakage of the packing at the second sealing part can more reliably be prevented.

[0010] In one embodiment, one of the sealing surfaces of the container and closure is a plane with the first and second regions made flush with each other, and the other sealing surface includes a step at a boundary between the first and second regions, one surface of the packing is a plane corresponding to the one sealing surface, and the other surface includes a step corresponding to the other sealing surface. Owing to this arrangement, the effect of the present invention can be obtained with a comparatively simple packing structure and sealing surface configuration.

[0011] In another embodiment, an annular projection is formed on one of the sealing surface of the container and the sealing surface of the closure, a top surface of the projection is provided as the second region, a radial inside and a radial outside of the projection in the one sealing surface are

provided as the first regions, the other sealing surface includes the second region and the first regions disposed radially inside and outside of the second region on a same plane in correspondence to one sealing surface, and the packing includes the thin second sealing part corresponding to the projection and the thick first sealing parts located radially inside and outside of the second sealing part. Owing to this arrangement, two sealing parts are employed and thus, liquid tightness can be enhanced.

[0012] According to another aspect of the present invention, there is provided a fuel sealing structure comprising a container for storing fuel and having an opening part, a closure attached to the opening part of the container, and an annular packing interposed in a compressed condition between an annular sealing surface of the container and an annular sealing surface of the closure, wherein an annular elastically deformable permeation restraining plate having a lower fuel permeability than material of the packing is embedded in the packing, the permeation restraining plate extends radially of the packing, a distance between the permeation restraining plate and one surface of the packing is shorter than that between the permeation restraining plate and the other surface of the packing at a certain annular part but a distance between the permeation restraining plate and the other surface of the packing is shorter than that between the permeation restraining plate and the one surface of the packing at other annular part.

[0013] Owing to the above construction, the gasified fuel is divided into two groups and permeates the packing material through one and the other sides of the permeation restraining plate. The first group of gasified fuel passing through one side of the permeation restraining plate is restrained in permeation at a place having a small permeating sectional area between a certain annular part of the permeation restraining plate and one surface of the packing, and the second group of gasified fuel passing through the other side of the permeation restraining plate is restrained in permeation at a place having a small permeating sectional area between the other annular part of the permeation restraining plate and the other surface of the packing. As a result, the total amount of the permeating gasified fuel can be restrained. Moreover, the packing is not required to be made thin in order to restrain the permeation of gasified fuel and the change of compression ratio can be made gentle with respect to the amount of axial movement of the closure. Thus, the compression ratio can be managed with a comparatively high precision and set within an allowable range. As a result, the packing can be adhered to the sealing surface of the container and the sealing surface of the closure with a sufficient pressure without the occurrence of breakage of the packing, and the leakage of liquid fuel can reliably be prevented.

[0014] Preferably, both surfaces of the packing are planes and have a uniform thickness, and the permeation restraining plate is inclined at a

surface connecting the certain annular part and the other annular part together. Owing to this arrangement, the packing can be made simple in structure.

#### EFFECT OF THE INVENTION

[0015] According to the present invention, a liquid fuel can satisfactorily be sealed. Also, a gasified fuel can satisfactorily be restrained in permeation. Moreover, breakage of the packing can be avoided.

#### BRIEF DESCRIPTION OF DRAWINGS

[0016] FIG. 1 is a vertical sectional view of a fuel sealing structure according to a first embodiment of the present invention.

[0017] FIG. 2 is an enlarged vertical sectional view of the sealing structure, showing a state of a packing immediately before its first sealing part is compressed.

[0018] FIG. 3 is an enlarged vertical sectional view of the sealing structure, showing a state of the packing wherein its first and second sealing parts are compressed and attachment of a closure is completed.

[0019] FIG. 4 is a graph showing the change of the compression ratios of the first and second sealing parts of the packing.

[0020] FIG. 5 is an enlarged vertical sectional view of a fuel sealing structure according to a second embodiment of the present invention.

[0021] FIG. 6 is an enlarged vertical sectional view of a fuel sealing structure according to a third embodiment of the present invention.

[0022] FIG. 7 is a graph showing the change of the compression ratios when a thin packing is used in the conventional fuel sealing structure.

#### DESCRIPTION OF REFERENCE NUMERALS

- 10...fuel tank (container)
- 11...opening part
- 15...sealing surface
- 15a...first region
- 15b...second region
- 20...pump (closure)
- 25...sealing surface
- 25a...first region
- 25b...second region
- 29...projection
- 30...packing
- 31...first sealing part
- 32...second sealing part
- 50...permeation restraining plate

## BEST MODE FOR CARRYING OUT THE INVENTION

[0023] A fuel sealing structure according to a first embodiment of the present invention will be described hereinafter with reference to FIGS. 1 through 4. In FIG. 1, reference numeral 10 denotes a fuel tank (container). The fuel tank includes a cylindrically projecting opening part 11. A screw 12 is formed on the outer periphery of this opening part 11.

[0024] A pump 20 (closure) can be attached to the opening part 11. An annular flange 21 projects from the outer periphery of the pump 20. An annular packing 30 is interposed in its compressed condition between a lower surface of the flange 21 and an upper end surface of the opening part 11 of the fuel tank 10.

[0025] The sealing structure further includes a cylindrical lock nut 40. A radially inwardly projecting annular hook part 41 is formed on an upper end of this lock nut 40 and a screw 42 is formed on an inner periphery of the lock nut 40. By bringing the lock nut 40 into threading engagement with the opening part 11 and tightening the lock nut 40, the hook part 41 is abutted with the flange 21 of the pump 20 such that the flange 21 is pushed downward. By this, the packing 30 is compressed to exhibit the sealing performance.

[0026] The details of the sealing structure will now be described with reference to FIGS. 2 and 3. FIG. 2 shows the packing 30 immediately before

it is compressed during the threading engagement process of the lock nut 40, and FIG. 3 shows the compressed packing 30 when the tightening of the lock nut 40 is completed (the attachment of the pump 20 is completed).

[0027] The upper end surface of the opening part 11 is provided as an annular sealing surface 15. This sealing surface 15 is stepped and includes a lower annular first region 15a and a higher annular second region 15b. In this embodiment, the second region 15b is located radially outside of the first region 15a. The lower surface of the flange 21 of the pump 20 is also provided as an annular sealing surface 25. This sealing surface 25 includes an annular first region 25a faced with the first region 15a of the sealing surface 15 and an annular second region 25b faced with the second region 15b. Those regions 15a, 15b, 25a, 25b constitute planes orthogonal to the axes of the opening part 11 and the pump 20. The regions 25a, 25b are flush with each other, and the sealing surface 25 is a continuous planar surface.

[0028] The packing 30 integrally includes a first sealing part 31 disposed between the first regions 15a, 25a and a second sealing part 32 disposed between the second regions 15b, 25b. An upper surface of the packing 30 is a planar surface and provided as an adhesion surface with the sealing surface 25 of the flange 21. A lower surface of the packing 30 is stepped. This step of the lower surface of the packing 30 corresponds to that of the sealing surface 15. The lower surface includes the two annular

planar surfaces, which are provided as adhesion surfaces to be adhered to the regions 15a, 15b of the sealing surface 15.

[0029] As shown in FIG. 2, a thickness THb of the second sealing part 32 in a natural condition (non-compressed condition) is smaller than a thickness THa of the first sealing part 31 in a natural condition. This thickness difference  $\Delta TH$  ( $\Delta TH = THa - THb$ ) is larger than a height of the step S between the regions 15a, 15b in the sealing surface 15. Because of this reason, with the flange 21 of the pump 20 merely placed on the packing 30, the upper and lower surfaces of the first sealing part 31 is in contact with the first regions 15a, 25a of the sealing surfaces 15, 25 and the upper surface of the second sealing part 32 is in contact with the second region 25b of the sealing surface 25. However, the lower surface of the second sealing part 32 is spaced away by a distance y ( $y = \Delta TH - S$ ) from the second region 15b of the sealing surface 15.

[0030] The above-mentioned step S refers to a difference between the distance between the first regions 15a, 25a and the distance between the second regions 15b, 25b at the time of beginning of the attachment of the pump 20 or completion of the attachment.

[0031] As previously mentioned, when the lock nut 40 is threadingly engaged with the opening part 11, first, the first sealing part 31 begins to be compressed. When the threading engagement of the lock nut 40 is

further progressed to push down the flange 21 of the pump 20 in the axial direction by  $y$  ( $y = \Delta TH - S$ ), the second sealing part 32 begins to be compressed. As shown in FIG. 3, by further progressing the threading engagement of the lock nut 40 to push down the flange 21 in the axial direction by  $\Delta y$ , attachment of the pump 20 is completed.

[0032] The compression ratio  $R1$  of the first sealing part 31 at the time of completion of the attachment can be expressed by the following equation.

$$R1 = (y + \Delta y)/THa \quad (1)$$

[0033] Likewise, the compression ratio  $R2$  of the second sealing part 32 can be expressed by the following equation.

$$R2 = \Delta y/THb \quad (2)$$

[0034] The compression ratio  $R2$  of the second sealing part 32 is smaller than the compression ratio  $R1$  of the first sealing part 31.

[0035] Changes of the compression ratios of the first and second sealing parts 31, 32 in accordance with the axial movement of the pump 20 are shown in FIG. 4.

[0036] As mentioned above, the compression ratio of the first sealing part 31 at the time of completion of the attachment of the pump 20 is such high as, for example, 10%, and its upper and lower surfaces are adhered to the first regions 15a, 25a of the sealing surfaces 15, 25 with a strong

adhering force. Accordingly, the leakage of the liquid fuel can reliably be prevented. Since the thickness THa of the first sealing part 31 is large, the sectional area through which the gasified fuel permeates the rubber material is large and the function for restraining the permeation of the gasified fuel is lower than the second sealing part 32 as later described.

[0037] The compression ratio of the second sealing part 32 at the time of completion of the attachment of the pump 20 is such low as, for example, 3%, and its upper and lower surfaces are adhered to the second regions 15b, 25b of the sealing surfaces 15, 25 with a weak adhering force. Accordingly, the function for preventing the leakage of the liquid fuel is weaker than the first closure 31. However, since the thickness THb of the second sealing part 32 is small and the permeating sectional area is small, the function for restraining the permeation of the gasified fuel is high.

[0038] As mentioned above, by preventing the leakage of liquid fuel mainly at the first sealing part 31 and restraining the permeation of gasified fuel mainly at the second sealing part 32, a satisfactory fuel-sealing characteristic can be obtained.

[0039] Some error of the compression ratio may occur due to error of the axial position of the flange 21 at the time of completion of the attachment of the pump 20. However, since the thickness THa of the first sealing part 31 is large and the change of the compression ratio with respect

to the amount of axial movement of the flange 21 is comparatively small, this compression ratio can be set within an allowable range of error. As a result, breakage due to overly high compression ratio does not occur and leakage of liquid fuel due to overly low compression ratio does not occur, either.

[0040] Since the thickness TH<sub>a</sub> of the second sealing part 32 is small and the change of the compression ratio with respect to the amount of axial movement of the flange 21 is comparatively large, the error of compression ratio becomes large. However, since the compression ratio R<sub>2</sub> is set to be lower than that of the first sealing part 31, the error is lower than the upper limit of the allowable range of error and the breakage can reliably be prevented. Since the lower limit of the range of error of the compression ratio of the second sealing part 32 is set to be equal to or higher than 1%, the gasified fuel never leaks between the second sealing part 32 and the second regions 15b, 25b of the sealing surfaces 15, 25.

[0041] Other embodiments of the present invention will be described next. In those embodiments, the component parts corresponding to the preceding embodiment are denoted by identical reference numeral and detailed description thereof will be omitted. FIG. 5 shows a second embodiment of the present invention. An annular projection 29 is formed on a sealing surface 25 of a flange 21. A flat surface of this projection 29 is provided as a second region 25b of the sealing surface 25, and the radially

inside and outside of a projection 29 are provided as a first region 25a. On the other hand, a sealing surface 15 on an opening part 11 includes, on a same plane, an annular second region 15b corresponding to the second region 25b and a first region 15 located radially inside and outside of the second region 25b. A packing 30 includes an annular groove corresponding to the projection 29 and a bottom part of this groove is provided a second sealing part 32, and the radially inside and outside parts of the second sealing part 32 is provided as a first sealing part 31 having a large thickness. The dimensions and compression ratios of the various component parts in this embodiment are same as in the first embodiment. In this embodiment, by using the first sealing parts 31 at two places, the liquid tight characteristic can further be enhanced.

[0042] FIG. 6 shows a third embodiment of the present invention. In this embodiment, an annular permeation restraining plate 50, which is made of material having a lower permeation ratio than the rubber material of the packing 30 such as, for example, metal and resin, is embedded in a packing 30 whose upper and lower surfaces are planar surfaces and having a uniform thickness. This permeation restraining plate 50 has a same sectional configuration over the entire periphery. The plate 50 is thin and elastically deformable and extends in the radial direction of the packing 30. At certain annular parts 51, 52 of the permeation restraining plate 50, a distance between an upper surface (one surface) of the packing 30 and the

permeation restraining plate 50 is smaller than a distance between a lower surface (the other surface) and the permeation restraining plate 50, thereby providing annular regions each having a smaller permeating sectional area in the packing 30. At another annular part 53, a distance between the lower surface of the packing 30 and permeation restraining plate 50 is smaller than a distance between the upper surface and the permeation restraining plate 50, thereby providing an annular region having a small permeating sectional area in the packing 30. The sealing surfaces 15, 25 form planar surfaces respectively corresponding to the upper and lower surfaces of the packing 30.

[0043] In the third embodiment, the packing 30 has a comparatively large thickness like the first sealing part 31 of the first embodiment. Accordingly, the packing 30 exhibits a performance on a satisfactory level with respect to the prevention of leakage of the liquid fuel caused by compression thereof. The permeation restraining plate 50 undertakes the permeation preventing function of the gasified fuel. That is, the gasified gas tries to permeate the packing 50 in two groups owing to a provision of the permeation restraining plate 50. The gasified fuel permeating through the upper side of the permeation restraining plate 50 is restrained in permeation here because the distance between the annular parts 51, 52 and the upper surface of the packing 30 is short and the permeating sectional area is small. On the other hand, the gasified fuel permeating through the lower

side of the permeation restraining plate 50 is restrained in permeation here because the distance between the annular part 53 and the lower surface of the packing 30 is short and the permeating sectional area is small. In this manner, the total amount of permeation of the gasified fuel can be restrained.

[0044] The present invention is not limited to the above-mentioned embodiments but many other embodiments may also be employed. For example, a step may be formed on the sealing surface 25 in the first embodiment. The projection 29 may be formed on the sealing surface 15 in the second embodiment. It is also accepted that the closure is a normal cover instead of the pump.

#### INDUSTRIAL APPLICABILITY

[0045] The present invention is applicable to a sealing structure for a fuel tank of automotive vehicles or the like.